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ABSTRACT

Assessment data and other research findings on fractions are briefly reviewed. These indicate that students are able to add and subtract fractions but have substantial difficulty finding and using common denominators. Selected results for nine-year-olds from the first and second national assessments of mathematics are used to portray what students can and cannot do. Implications for instruction are then noted: developing the concepts for fractions earlier, or reversing the sequence of fractions and decimals in the curriculum, is each suggested. (MNS)

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Findings of several studies are summarized and brief pedagogical suggestions are presented.

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WHAT STUDENTS IN THE INTERMEDIATE GRADES DON'T KNOW ABOUT FRACTIONS AND WHAT TO DO ABOUT IT

Patricia Bachelor and Aaron Buchanan

Results of NAEP assessments, data from a variety of state assessments, and other research findings are generally consistent. Most students are able to add and subtract like fractions but have substantial difficulty finding and using common denominators. When adding fractions, the most common error pattern is to add the numerators and denominators. The major difficulty in multiplying fractions is reducing the answers to lowest terms. Romberg (1968) noted that many students seem to know the algorithm but they make errors in reducing their answers and/or fail to use a cancellation procedure in their multiplication. Lankford (1972) pointed to another error frequently made by students when multiplying fractions. The students interviewed wrote the fractions with common denominators first, then multiplied only the numerators, and lastly placed the product over the common denominator. For example:

$$2/3 \times 3/5 = 10/15 \times 9/15 = 90/15.$$

The difficulties of division are compounded by the confusion over which fraction to invert.

Selected results from the first NAEP assessment reveal that only 20 to 37% of the nine-year-olds demonstrate a basic knowledge of key fraction concepts. In particular, most students in this age group lack knowledge of the basic concepts rather than possess erroneous notions. In fact, nine-year-olds are apparently so unfamiliar with identifying the

fractional part of shaded figures that 9 to 16% responded "I don't know" to this type of item and 24 to 46% answered by attempting to name the shaded part. Sixty percent of this group of respondents were also unable to apply the fractional concept needed to correctly answer items that involved identifying the fractional part resulting from division of an item into equal pieces.

Specific findings from the second NAEP assessment indicate that at age nine,[1] the underpinning concepts and models of fractions are not well developed. This conclusion is based upon performance on the 40 test items which involved only fractions. Approximately half of these dealt with fraction concepts, equivalency, or language; about one-fourth focused upon computation; and the remaining one-fourth was word problems. The exercises which dealt with the language of fractions required the students to write or choose the symbol representing a verbally described fraction. A majority of the students were able to select the correct symbol and slightly more than one-half could write the correct symbol for the fraction. Seven-eighths of the students were able to write the symbol for most any proper fraction. When faced with exercises in which a region is shown that is divided into the same number of parts as the

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[1]Keep in mind that the NAEP sample of nine-year-old students included some students in grade 3, where common fractions are first introduced, and some in grade 4, where skills with fractions are retaught and then extended substantially. Unfortunately, the lessons on fractions in many third and fourth grade textbooks come in the last quarter of the textbook, while the second NAEP assessment occurred near the middle of the school year. Therefore, it's a fairly safe bet that many third grade students among NAEP nine-year-olds had little if any previous experience with fractions, while fourth grade students had not had any instruction since last year, and then only if their teachers got to the last parts of their textbooks.

denominator of the fraction, 62% of the nine-year-olds were able to successfully shade the region to show the fraction. However, this group experienced much more difficulty when the region was divided into more parts than the number in the denominator. There, only 20% answered correctly. Similarly, almost 80% of nine-year-olds were unable to write a fraction that was represented in a set model. In fact, more than half of the students answered with the number of items and not the fractional part they represented. Perhaps the use of items that required, in general, a constructed response may account for some, if not most, of the difficulty students had with these types of "fractions as sets" items. Another possibility is that the inexperienced students may use multiple choice options as cues to solve the problems and base their selection of a correct response on how easy it is to "see" numbers that might be relevant in the answer choices. Only half of the nine-year-olds knew how many parts (halves, thirds, etc.) made a whole. Computations with fractions posed the most problems for this age group since they have limited experience adding fractions. The results of the items in which the students were required to add fractions with or without common denominators were missed with the most regularity.

Replicated evidence indicates that a large percentage of students leaving elementary and junior high school have limited skills with fractions and very little conceptual understanding. Why? One reason is that somewhere back along the line risks were taken. Sometimes these risks took the form of decisions to "introduce" a topic rather than teach a concept or skill to the point where all or nearly all students had some

identifiable proficiency that later instruction could build upon. More often decisions made were simply to defer instruction on a skill or concept until "next year." The consequences of these risks amount to lost opportunities for students to learn within the mainstream of instruction, not just this year, but next year, the year after, and the year after that.

What to do about it? The instruction requires earlier attention in schooling than it usually receives. Students are not likely to go far with the algorithms without a better understanding of the concept. But it is almost too late to work on the whole/part concepts in grade 4, where students are expected to identify equivalent fractions and perform simple computation with fractions. A cautious approach to the conceptual aspects of fractions is to teach them in the last quarter of grade 2, or at least early in grade 3. The substance of the instruction is no more complicated than other instructional matters that 2nd graders are now handling well.

Alternatively, with the current accessibility of calculators and the increasing accessibility of computers, it makes sense to switch the conventional placement of decimals and fractions in the sequence of elementary instruction: teaching the recognition of decimals, the computation of decimals, and decimal to fraction conversion, before taking up the complex algorithms for computing with fractions.

Neither of these alternatives will make instruction any more difficult for students and either or both will go a long way toward "solving the fraction's problem."

References

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